
OBSTETRICS

A Risk Score for Predicting Postpartum Hemorrhage in Association with Cesarean Delivery

Jurarut Suta, MD*,
Somnimit Leungratsameerung, MD*,
Chadakarn Phaloprakarn, MD*.

* Department of Obstetrics and Gynecology, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok 10300, Thailand

ABSTRACT

Objective: To determine the prevalence of postpartum hemorrhage (PPH) in association with cesarean delivery and to develop a risk score for predicting PPH in women who underwent cesarean delivery based on clinical characteristics.

Methods: A retrospective study was conducted on 2,405 pregnant women who underwent cesarean delivery in our institution between September 2011 and December 2013. Clinical data were collected from medical records. The potential risk factors of PPH were determined by multivariable logistic regression. Risk score was constructed according to the coefficient of each significant variable in the regression model.

Results: The prevalence of PPH in cesarean delivery was 10.1%. According to the multivariable analysis, advanced maternal age, race (other Asian nations), multiparity, placenta previa, emergency cesarean delivery, fetal macrosomia, and abnormal second stage of labor were significantly associated with PPH in cesarean delivery. These seven factors were incorporated into a risk score which produced a sensitivity of 60.2% and specificity of 18.1% at the optimal cutoff score of ≥ 3 .

Conclusions: PPH is prevalent in women undergoing cesarean delivery. A risk score based on clinical characteristics might be a useful tool for predicting PPH in cesarean delivery.

Keywords: Risk score, postpartum hemorrhage, PPH, cesarean delivery

Correspondence to: Somnimit Leungratsameerung, MD., Department of Obstetrics and Gynecology, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, 681 Samsen Road, Dusit district, Bangkok 10300, Thailand. Tel: +66 1375-0445 Fax: +66 2243 7907, E-mail: lsomnimit@yahoo.com

Introduction

Over the past decades, the prevalence of cesarean delivery has increased dramatically due to the advances in medical technology and increasing

demand from pregnant women⁽¹⁾. The disadvantage of cesarean delivery is that it can cause serious complications including massive hemorrhage, which can lead to maternal morbidity and mortality⁽²⁾.

Postpartum hemorrhage (PPH) in cesarean delivery was usually defined as blood loss greater than 1,000 ml and/or maternal hemodynamic instability or anemic condition necessitating blood transfusion⁽³⁾. Its prevalence rates have been reported to be varied, ranging from 2.4% to 18%⁽⁴⁻⁶⁾. Because PPH is commonly found in cesarean delivery, many studies attempted to identify risk factors of PPH in relation to this obstetric procedure. Gilstrap et al⁽⁷⁾, reported that general anesthesia was associated with greater amount of blood loss than regional anesthesia while Kamani et al⁽⁸⁾, found that transfusion was required more often among women who needed emergency cesarean delivery than elective cesarean delivery. Another study also observed that excessive bleeding during abdominal delivery was related to general anesthesia, chorioamnionitis, preeclampsia, and many abnormal conditions during labor phase, such as protracted active phase and arrest of descend⁽⁹⁾. Nevertheless, there has been no study which incorporates such potential risk factors into a risk score to predict the possibility of PPH in cesarean delivery. We performed this study in order to evaluate the prevalence of PPH in cesarean delivery and determine the possibility of integrating maternal and obstetric characteristics into a prediction model to predict the risk score of developing PPH in cesarean delivery.

Material and Methods

This study received approval from the Vajira Institutional Review Board, protocol code 035/56. Before performing this study, we conducted a pilot investigation on a cohort of 130 women who underwent cesarean delivery in our institution between July 1, 2011 and August 31, 2011. The estimated blood loss in our institution was assessed by visually estimated of blood-soaked surgical swabs plus measured volume of blood loss in suction drain bottle by the attending staff (obstetrician, anesthetist, and the scrub nurse). This study included the women who had the estimated blood loss equal or more than 1,000 ml as a PPH from cesarean delivery. Based on this pilot investigation, the prevalence of PPH was about 11.5% with a sensitivity of 80% and specificity of 34.8% of the

prediction model. Using this information along with 5% chance of making a type I error and the maximum allowable error of 5%⁽¹⁰⁾. A total number of women needed was 2,138. Giving a 20% drop out rate, the sample size was raised to 2,566.

The eligibility criteria were women with a singleton pregnancy at any gestational age who underwent cesarean delivery in our institution between September 2011 and December 2013. The exclusion criteria were incomplete data records, maternal history of bleeding tendency, and fetal death in utero. Data collection included maternal age, race, parity, pregnancy and delivery body mass index (BMI [kg/m²]), history of previous cesarean section, history of previous abdominal surgery, hypertension and diabetes (DM) history, obstetric data including the presence or absence of placenta previa, antepartum hemorrhage, induction of labor, any abnormal conditions during the first or second stage of labor, cervical dilatation, presentation of the fetus, birth weight, mode of anesthesia, level of surgeon, operative time, and estimated blood loss. Abnormal first stage of labor was included prolong latent phase that defined as the latent phase take time more than 20 hours in nullipara and 14 hours in multipara between onset of labor and active phase, and protract active phase of labor that define as cervical dilatation from 4 to 10 cm more than 4 hours. Abnormal second stage of labor in this study was diagnosed when secondary arrest of descend after complete cervical dilatation (10 cm) and prolong second stage of labor (in nulliparas > 3 hours with epidural, > 2 hours without an epidural; in multiparas > 2 hours with epidural, >1 hour without an epidural)⁽¹¹⁻¹²⁾.

Statistical analysis was performed with SPSS software package version 22.0. Continuous variables were presented as mean with standard deviation. Categorical variables were presented as frequency and percentage. Chi-Square test was used to compared categorical variables. Univariable analysis was performed to determine risk factors, which were significantly related to PPH. Secondly, only significant factors ($p < 0.05$) were applied to multivariable analysis in order to determine odds of PPH in each factor. The variables that were significantly associated with PPH

by Chi-Square test were entered into a logistic regression model. A risk score was then developed from the β coefficient value of each significant variable from this regression model; weighted points proportional to the coefficient values (rounded to the nearest integer) were assigned. A receiver operating characteristic (ROC) curve and area under the curve (AUC) were calculated to determine the optimal score for predicting PPH. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) with associated 95% confidence interval (CI) of each cutoff point were presented.

Results

Among 2566 women included during the study

period, 155 women had incomplete medical records, 4 had a history of bleeding tendency, and 2 had fetal death in utero. Hence, 2,405 women were included for analysis. Baseline characteristic of these women are presented in Table 1. All of The PPH associated with cesarean delivery was 10.1% and the mean estimated blood loss was 572.1 ml. Compared characteristic features between women who had and did not have PPH. We found that the significant factors for PPH were advanced maternal age⁽¹³⁾, race (other Asian nations), multiparity, pre-pregnant BMI, history of gestational diabetic mellitus (GDM) or overt DM, placenta previa, condition of emergency cesarean delivery, fetal macrosomia, abnormal second stage of labor, and cervical dilatation ≥ 7 cm.

Table 1. Baseline characteristics of women who undergoing cesarean section with or without presenting of PPH.

Characteristic	n = 2405		P [†]
	PPH (%)	no PPH (%)	
Number of women	244 (10.1)	2161 (89.9)	
Age (years)			0.001
Normal age (20-34)	160 (56.6)	1482 (68.6)	
Teenage (< 20)	11 (4.5)	211 (9.8)	
Advanced age (≥ 5)	73 (29.9)	468 (21.7)	
Race			0.003
Thai	218 (89.3)	2036 (94.2)	
Other Asians	26 (10.7)	125 (5.8)	
Parity			0.002
Nullipara	95 (38.9)	1068(49.4)	
Multipara	149 (61.1)	1093 (50.6)	
Prepregnant BMI (kg/m²)			0.034
Normal weight (20.0 - 24.9)	109 (44.7)	901 (41.7)	
Underweight (< 20.0)	58 (23.8)	701 (32.4)	
Overweight (25.0 - 29.9)	55 (22.5)	383 (17.7)	
Obesity (≥ 30)	22 (9.0)	176 (8.1)	
Delivery BMI (kg/m²)			0.051
Normal weight (20.0 - 24.9)	42 (17.2)	487 (22.5)	
Underweight (< 20.0)	0 (0)	32 (1.5)	
Overweight (25.0 - 29.9)	116 (47.5)	940 (43.5)	
Obesity (≥ 30)	86 (35.2)	702 (32.5)	
History of previous cesarean delivery			0.065
No	196 (80.3)	1620 (75.0)	
Yes	48 (19.7)	541 (25.0)	

Table 1. Baseline characteristics of women who undergoing cesarean section with or without presenting of PPH. (Cont.)

Characteristic	n = 2405		P†
	PPH (%)	no PPH (%)	
History of previous abdominal surgery			0.569
No	233 (95.5)	2045 (94.6)	
Yes	11 (4.5)	116 (5.4)	
Chronic hypertension / PIH			0.990
No	212 (86.9)	1877 (86.9)	
Yes	32 (13.1)	284 (13.1)	
Overt DM / GDM			0.018
No	217 (88.9)	2012 (93.1)	
Yes	21 (11.1)	149 (6.9)	
Placenta previa			< 0.001
No	233 (95.5)	2135 (98.8)	
Yes	11 (4.5)	26 (1.2)	
Antepartum hemorrhage			0.67
No	240 (98.4)	2148 (99.4)	
Yes	4 (1.6)	13 (0.6)	
Condition			0.044
Elective	51 (20.9)	518 (26.9)	
Emergency	193 (79.1)	1580 (23.1)	
Fetal presentation			0.185
Cephalic	203 (83.2)	1865 (86.3)	
Breech/transverse	41 (16.8)	296 (13.7)	
Birth weight (g)			0.001
Normal weight (2,500 - 3,999)	208 (85.2)	1805 (83.5)	
Low birth weight (< 2,500)	16 (6.6)	269 (12.4)	
Macrosomia (≥ 4,000)	20 (8.2)	87 (4.0)	
Anesthesia			0.091
General anesthesia	105 (43.0)	810 (37.5)	
Spinal block	139 (57.0)	1351 (62.5)	
Surgeon			0.194
Staff	82 (33.6)	818 (37.9)	
Resident	162 (66.4)	1343 (62.1)	
Induction of labor			0.383
No	100 (53.5)	908 (56.8)	
Yes	87 (46.5)	690 (43.2)	
Abnormal 1st stage of labor			0.563
No	109 (58.3)	896 (56.1)	
Yes	78 (41.7)	702 (43.9)	

Table 1. Baseline characteristics of women who undergoing cesarean section with or without presenting of PPH. (Cont.)

Characteristic	n = 2405		P [†]
	PPH (%)	no PPH (%)	
Abnormal 2nd stage of labor			< 0.001
No	167 (89.3)	1541 (96.4)	
Yes	20 (10.7)	57 (3.6)	
Cervical dilatation before cesarean delivery			0.002
< 7 cm	201 (86.3)	1968 (92.2)	
7-10 cm	32 (13.7)	167 (7.8)	

[†]Chi square test

Other Asian nations = Cambodian, Myanmar; Body Mass Index (BMI [kg/m²]) = weight (kg) / height(m)²; PIH = Pregnancy induced hypertension; GDM = Gestational diabetic mellitus

In multivariable analysis of these ten variables (Table 2), only advanced maternal age, other Asian nations, multiparity, placenta previa, emergency cesarean delivery, birth weight \geq 4,000 g. and abnormal second stage of labor were identified as significant factors associated with PPH among pregnant women undergoing cesarean delivery. Based on the final

model, their odds ratio were 1.40 (95% CI 1.03-1.90), 1.70 (95% CI 1.07-2.69), 1.48 (95% CI 1.12-1.96), 4.37 (95% CI 2.08-9.15), 1.56 (95% CI 1.12-2.19), 1.92 (95% CI 1.14-3.23), and 2.81 (95% CI 1.63-4.85), respectively. The sensitivity, specificity, PPV, and NPV of the risk score at different cutoff values to predict PPH are shown in Table 3. The total score ranged from -2 to 14.

Table 2. Multivariable analysis to determine odds ratio for risk factors of PPH associated with cesarean delivery.

Characteristics	First full model			Final model			Score*
	Coefficient	OR**	95%CI	Coefficient	OR**	95%CI	
Age (years)							
Normal age (20 - 34)	Reference	-	-	Reference	-	-	0
Teenage (< 20)	- 0.528	0.59	(0.31-1.12)	- 0.586	0.56	(0.29-1.05)	0
Advanced age (\geq 35)	0.309	1.36	(1.00-1.85)	0.336	1.40	(1.03-1.90)	1
Race							
Thai	Reference	-	-	Reference	-	-	0
Other Asians	0.519	1.68	(1.06-2.66)	0.530	1.70	(1.07-2.69)	2
Parity							
Nullipara	Reference	-	-	Reference	-	-	0
Multipara	0.370	1.45	(1.09-1.92)	0.394	1.48	(1.12-1.96)	1
BMI (kg/m²)							
Normal weight (20.0 - 24.9)	Reference	-	-	-	-	-	-
Underweight (< 20)	- 0.253	0.78	(0.55-1.09)	-	-	-	-
Overweight (25 - 29.9)	0.091	1.09	(0.77-1.56)	-	-	-	-
Obesity (\geq 30)	- 0.143	0.87	(0.53-1.43)	-	-	-	-

Table 2. Multivariable analysis to determine odds ratio for risk factors of PPH associated with cesarean delivery. (Cont.)

Characteristics	First full model			Final model			Score*
	Coefficient	OR**	95%CI	Coefficient	OR**	95%CI	
Placenta previa							
No	Reference	-	-	Reference	-	-	0
Yes	1.508	4.52	(2.15-9.48)	1.474	4.37	(2.08-9.15)	4
Birth weight (g)							
Low birth weight (< 2500)	-0.690	0.51	(0.29-0.86)	-0.735	0.48	(0.28-0.82)	-2
Macrosomia (≥ 4000)	0.599	1.82	(1.08-3.08)	0.654	1.92	(1.14-3.23)	2
Condition							
Elective	Reference	-	-	Reference	-	-	0
Emergency	0.431	1.54	(1.09-2.16)	0.448	1.56	(1.12-2.19)	1
Abnormal 2nd stage of labor							
No	Reference	-	-	Reference	-	-	0
Yes	0.928	2.53	(1.30-4.91)	1.034	2.81	(1.63-4.85)	3
Cervical dilatation (cm)							
< 7	Reference	-	-	-	-	-	-
7-10	0.181	1.20	(0.71-2.01)	-	-	-	-

*Score = Point was assigned to each factor based on its coefficient value. Each coefficient was dividing by 0.309 (the lowest value) and rounded to the nearest integer.

**OR = Odds ratio

Table 3. Performances of the risk score at different cutoff values to predict PPH.

Cutoff score ≥	Number of women with score at cutoff level	% PPV [†] (95% CI)	% NPV ^{††} (95% CI)	% Sensitivity (95% CI)	% Specificity (95% CI)	AUC ^{†††}
-2	11	0	93.8 (0.93-0.95)	0 (0-0.32)	100 (0.99-1.00)	0.500
-1	118	0 (0-0.32)	89.8 (0.89-0.90)	0 (0-0.02)	99.5 (0.99-1.00)	0.503
0	235	3.9 (0.01-0.09)	89.5 (0.88-0.90)	2.0 (0.01-0.05)	94.2 (0.93-0.95)	0.518
1	913	4.7 (0.03-0.08)	88.9 (0.87-0.90)	6.9 (0.04-0.11)	83.9 (0.82-0.85)	0.545
2	638	6.5 (0.05-0.08)	85.7 (0.84-0.88)	34.0 (0.28-0.40)	44.7 (0.43-0.47)	0.606
3	273	7.7 (0.06-0.09)	80.2 (0.76-0.84)	60.2 (0.54-0.66)	18.1 (0.16-0.20)	0.608
4	130	9.0 (0.08-0.10)	78.8 (0.73-0.84)	81.1 (0.76-0.86)	7.9 (0.07-0.09)	0.555
5	46	9.4 (0.08-0.11)	70.1 (0.59-0.79)	89.3 (0.85-0.93)	2.8 (0.02-0.04)	0.539
6	24	9.7 (0.08-0.11)	65.8 (0.49-0.79)	94.2 (0.90-0.97)	1.2 (0.01-0.02)	0.522
7	12	9.9 (0.09-0.11)	58.8 (0.33-0.80)	97.1 (0.94-0.99)	0.5 (0-0.01)	0.512
8	3	10.1 (0.09-0.11)	0.6 (0.17-0.93)	99.1 (0.97-0.99)	0.1 (0-0.01)	0.503
10	0	10.1 (0.09-0.11)	0 (0-0.80)	99.2 (0.97-0.99)	0 (0-0.01)	0.543

[†]PPV = Positive predictive value, ^{††}NPV = Negative predictive value, ^{†††}AUC = Area under the curve

The ROC curve of the risk score for predicting PPH in cesarean delivery demonstrated an overall AUC of 0.647 (95% CI 0.61-0.68) (Fig. 1). The cutoff

score of ≥ 3 which yielded the highest AUC gave a sensitivity of 60.2%, specificity of 18.1%, PPV 7.7%, and NPV 80.2%.

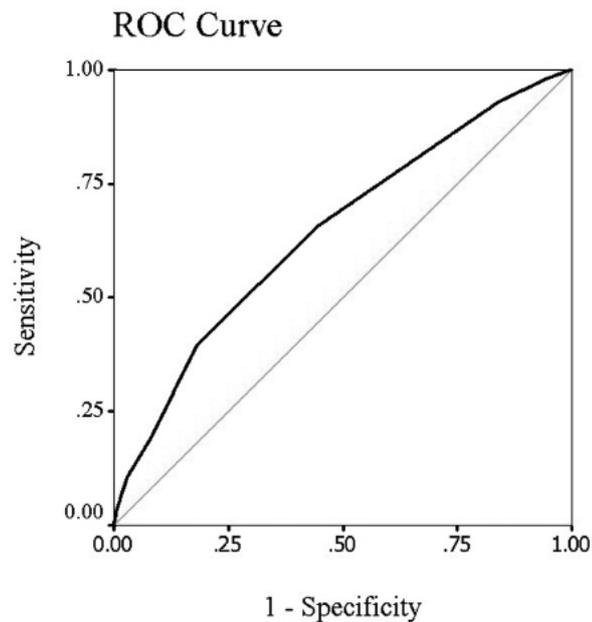


Fig. 1. The ROC curve of the risk score for predicting PPH in cesarean delivery.

Discussion

The prevalence of PPH in women undergoing cesarean delivery in our study population was 10.1% which was in the range of 7.2% to 27.5% reported by other authors⁽¹⁴⁾. We found that advanced maternal age, other Asian nations, multiparity, placenta previa, emergency cesarean delivery, fetal macrosomia, and abnormal second stage of labor were independent risk factors for PPH. The most significant factor was placenta previa which had an adjusted odds ratio of 4.37 (95% CI, 2.08-9.15). The significant factors for PPH observed in our study were confirmed by previous studies^(3,7-9). Sahota et al reported an association of advanced maternal age with an increased risk of PPH in a group of Pakistani women who underwent cesarean delivery. A possible explanation of this relationship might be that elderly mothers are prone to uterine atony⁽¹⁶⁾. Similarly, emergency cesarean delivery, fetal macrosomia, multiparity, the presence of placenta

previa, and abnormal second stage of labor have been found to be associated with PPH by Everett et al, Toril et al, and Combs et al^(3,8,9). The reason for these might be that these conditions also increase the probability of poor uterine contractility leading to uterine atony⁽¹⁷⁻²⁰⁾. In addition, our study observed that other Asian nations gravidas were at risk of PPH. This result could be explained by the fact that these women were migrant workers with low socioeconomic status, so many of these experienced anemia. It is known that preoperative anemia is related to perioperative blood loss as well as blood transfusion⁽²¹⁾. This is therefore a positive reason.

As PPH is a major cause of maternal morbidity and mortality worldwide, especially in low-resource countries, we therefore aimed to develop a simple and effective tool to predict PPH in women undergoing cesarean delivery which could be used in routine clinical practice. Our risk score consisted of seven maternal and obstetric characteristics which can be easily

obtained from history taking and physical examination. Regarding the optimal cutoff point for prediction high-risk woman for PPH, the cutoff score that produced the highest AUC was ≥ 3 . At this cutoff point, it yielded a sensitivity of 60.2%. With its modest sensitivity, this cutoff score might not be appropriate for the use to screen for PPH since as high as 19.8% of women would have a false negative result. Given that the purpose of a screening test is that it should have a high sensitivity for the detection of women who should be closely monitored, we proposed that a cutoff value of ≥ 3 might be more suitable because it could include as high as 91.0% of pregnant women. But the risk score in this study needs further study to validate the performance.

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ดัชนีความเสี่ยงสำหรับทำนายภาวะตกเลือดหลังคลอดจากการผ่าตัดคลอด

จุฬารัตน์ สุতা, สมณมิตร เหลืองรัศมีรุ่ง, ซาดากานต์ ฝิโลประการ

วัตถุประสงค์: เพื่อหาความชุกของภาวะตกเลือดหลังคลอดจากการผ่าตัดคลอด และสร้างดัชนีความเสี่ยงสำหรับทำนายภาวะตกเลือดหลังคลอดในหญิงตั้งครรภ์ที่เข้ารับการผ่าตัดคลอด

วัสดุและวิธีการ: ศึกษาย้อนหลังในหญิงตั้งครรภ์จำนวน 2,405 คน ที่เข้ารับการผ่าตัดคลอดที่คณะแพทยศาสตร์วชิรพยาบาล มหาวิทยาลัยนวมินทราชูติราช ช่วงเดือนกันยายน พ.ศ. 2544 ถึงเดือนธันวาคม พ.ศ. 2546 โดยทำการเก็บข้อมูลจากใบบันทึกเวชระเบียนผู้ป่วย จากนั้นนำข้อมูลมาคำนวณในสมการการวิเคราะห์ถดถอยพหุคูณ ให้ได้ค่าสัมประสิทธิ์เบต้าเพื่อนำมาคำนวณเป็นค่าดัชนีความเสี่ยง

ผลการศึกษา: จากการศึกษพบว่าความชุกของภาวะตกเลือดหลังคลอดจากการผ่าตัดคลอดคือร้อยละ 10.1 และจากสมการการวิเคราะห์ถดถอยพหุคูณพบว่า ปัจจัยที่มีความสัมพันธ์กับภาวะตกเลือดหลังคลอดจากการผ่าตัดคลอดอย่างมีนัยสำคัญได้แก่ หญิงตั้งครรภ์อายุมากกว่า 35 ปี, เชื้อชาติ (พม่า, กัมพูชา), หญิงที่ผ่านการตั้งครรภ์มากกว่า 1 ครั้ง, การมีรกเกาะต่ำ, การผ่าตัดคลอดแบบฉุกเฉิน, ทารกตัวโต (น้ำหนักแรกคลอดมากกว่า 4,000 กรัม), และหญิงตั้งครรภ์ที่มีการดำเนินการคลอดระยะที่ 2 ผิดปกติ ซึ่งเมื่อปัจจัยดังกล่าวนี้นำมาสร้างเป็นดัชนีความเสี่ยงพบว่า หญิงตั้งครรภ์ที่มีค่าคะแนนความเสี่ยง ≥ 3 คะแนน มีโอกาสเกิดภาวะตกเลือดหลังคลอดจากการผ่าตัดคลอด ที่ความไวร้อยละ 60.2 และความจำเพาะร้อยละ 18.1

สรุป: ภาวะตกเลือดหลังคลอดพบได้บ่อยในหญิงตั้งครรภ์ที่เข้ารับการผ่าตัดคลอด ดังนั้นดัชนีความเสี่ยงเพื่อทำนายภาวะตกเลือดหลังคลอดจากการผ่าตัดคลอดจึงมีประโยชน์อย่างมากสำหรับนำไปใช้ทางคลินิก
